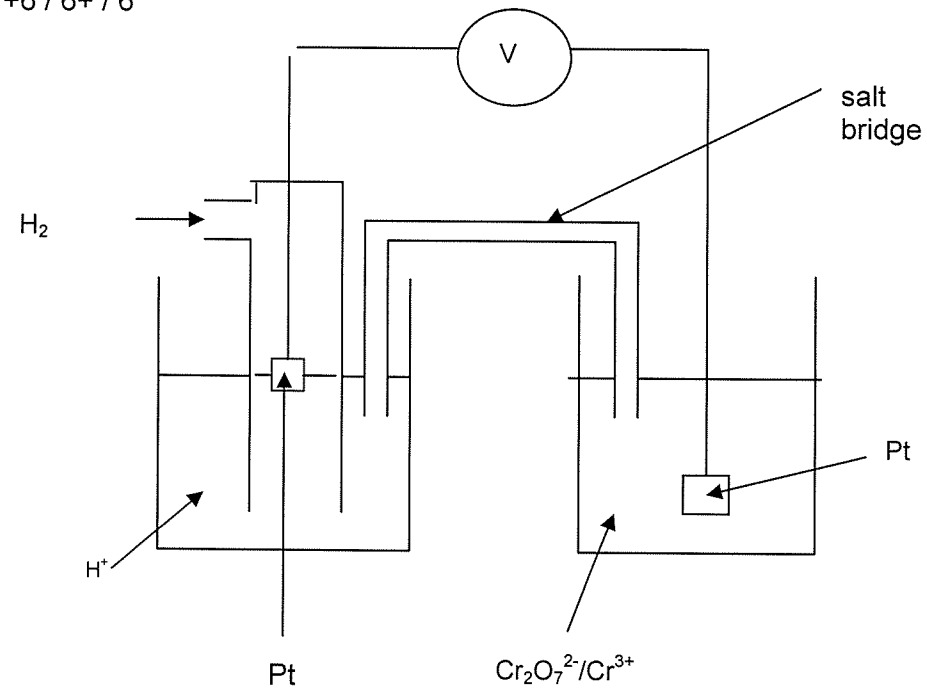
2815/01 Trends and Patterns

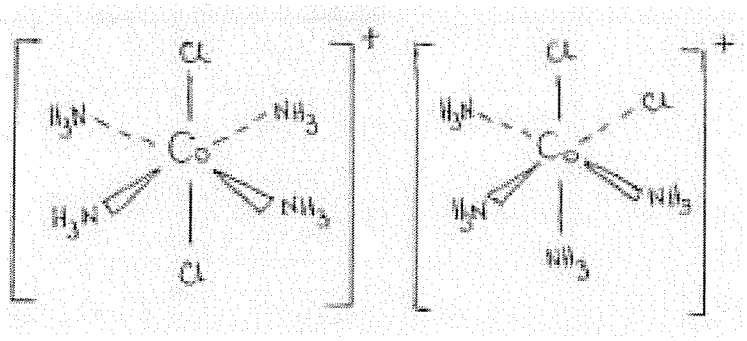
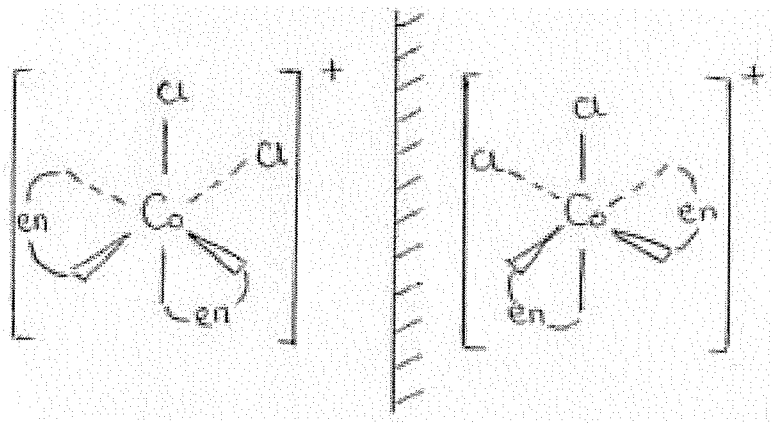
Question	Expected Answers	Marks	Additional Guidance
1 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ (1)	1	
(b) (i)	Correct formula of a copper(II) complex ion e.g. $CuCl_4^{2-}$ / $[Cu(NH_3)_4(H_2O)_2]^{2+}$ / $[Cu(H_2O)_6]^{2+}$ (1)	1	
(ii)	Correct colour (1) e.g. $CuCl_4^{2-}$ green/yellow, $[Cu(NH_3)_4(H_2O)_2]^{2+}$ dark blue and $[Cu(H_2O)_6]^{2+}$ blue	1	**Allow** ecf from a known copper compound
(iii)	Coordinate bond / dative bond (1) Lone pair donated by ligand / lone pair accepted by copper (1)	2	
(c) (i)	Blue precipitate / blue solid	1	Can get credit for ppt from state symbol of correct product in part (ii)
(ii)	$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$ / $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2 + 6H_2O$ / $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(H_2O)_4(OH)_2 + 2H_2O$ (1)	1	**Allow** correct multiples **Ignore** state symbol
(d) (i)	Mole ratio C:Cu:K:N = 0.0320:0.00800:0.0240:0.0320 (1) $K_3CuC_4N_4$ (1)	2	**Allow** the four masses ÷ appropriate A_r if mole ratio not calculated **Allow** any order of atoms Can award formula mark if given in part (ii) **Allow** ecf from wrong mole ratio
(ii)	$[Cu(CN)_4]^{3-}$ / $CuC_4N_4^{3-}$ (1)	1	**Allow** any order of atoms with or without brackets **Allow** ecf from wrong formula
	Total	10	

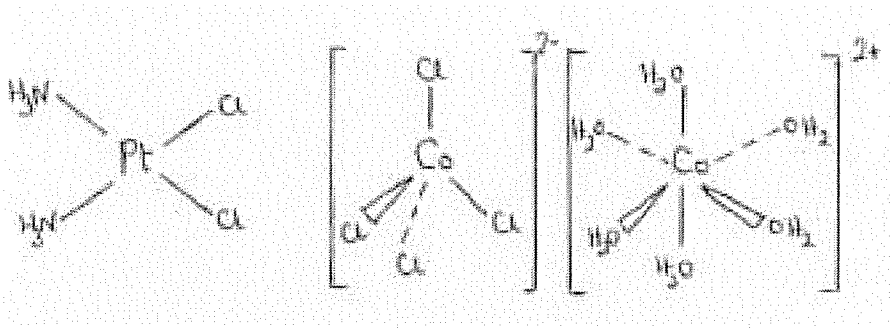
Question	Expected Answers	Marks	Additional Guidance
3 (a)	$2Cr^{3+} + 3H_2O_2 + 10OH^- \rightarrow 2CrO_4^{2-} + 8H_2O$ Correct reactants and products (allow e^- and OH^- on **both** left and right) and correct molar ratio of Cr^{3+} and H_2O_2 (1); Balanced (1)	2	For the second mark the OH^- and e^- must be cancelled down
(b)	Moles MnO_4^- = 0.000463 (1) Moles Fe^{2+} = 5 × moles MnO_4^- / 0.002315 (1) M_r = 392 / 391.8 (1) x = 6 (1) **dependent** on M_r given	4	**Allow** ecf within the question ecf is 0.907 ÷ moles of Fe^{2+} **Allow** three marks for 392 / 391.8 with no working ecf is (M_r – 283.8) ÷ 18 **Allow** one mark for 6 with no working
	Total	**6**	

2815/06 Transition Elements

Question	Expected Answers	Marks
1 (a) (i)	+6 / 6+ / 6	1
(ii)		
	H_2 and H^+ (state symbols not required)	1
	Voltmeter and salt bridge [if no liquid levels lose this mark]	
	Both Platinum electrodes labelled	1
	$Cr_2O_7^{2-}$ / Cr^{3+}(/ H^+ not needed for mark)	1
	Temp 298K or 25°C + Pressure 1 Atm / 100 kPa/ 101 KPa / 1 bar / 10^5 Pa	1
	+ concentration 1 mol dm^{-3} (can take from diagram) or equimolar mixture of $Cr_2O_7^{2-}$ / Cr^{3+}	1
(b)	$E^{\ominus}$ would be lower than +1.33 V	1
	Equilibrium would move from right to left / backwards	1
	Total	**8**
2 (a)	$[Co(H_2O)_6]^{3+}$	1
	$E^{\ominus}$ for $[Co(H_2O)_6]^{3+} + e^- \rightleftharpoons [Co(H_2O)_6]^{2+}$ is more positive	
	This reaction is more likely to proceed from left to right / $[Co(H_2O)_6]^{3+}$ is more likely to accept electrons / be reduced	1 1
(b)	Pink	1
(c)	$2[Co(NH_3)_6]^{3+} + Fe \rightarrow 2[Co(NH_3)_6]^{2+} + Fe^{2+}$	1
	idea that $E^{\ominus}$ is positive / idea of cobalt complex equilibrium tending to go from left to right whilst Fe^{2+} / Fe equilibrium goes from right to left / calculation of cell emf ((+)0.55V).	1
	Total	**6**

Question	Expected Answers	Marks
3 (a) (i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$	1
(ii)	Colour requires electrons in d-orbitals and a space for promotion / colour results from transitions of electrons between d-orbitals / colour results from a partially filled d-subshell	1
	Cu^+ has a full set of 3d orbitals / is $3d^{10}$ / has a full d-subshell	1
(b)	Energy levels of d-orbitals are split	1
	Different ligands interact differently with d-orbitals / ΔE changes for different ligands	1
	Size of ΔE determines frequency / wavelength / colour of visible light absorbed	1
(c)	Disproportionation or explained eg copper(I) goes to copper(II) and copper / copper(I) is oxidised and reduced.	1
	$2CuCl \rightarrow CuCl_2 + Cu$ / $2Cu^+ \rightarrow Cu^{2+} + Cu$	1
	$CuCl_2$ / Cu^{2+} / $[Cu(H_2O)_6]^{2+}$ and $CuCl_4^{2-}$ is blue-green and Cu is reddish-pink (both needed for 1 mark)	1
(d)	Moles $S_2O_3^{2-}$ = 0.00198 mol	1
	1 mole $S_2O_3^{2-}$ = 1 mole Cu^{2+} / 25 cm^3 Cu^{2+} contains 0.00198 moles	1
	250 cm^3 of Cu^{2+} contains 0.0198 moles	1
	0.0198 moles Cu has a mass of 0.0198 x 63.5 g = 1.26 g (1.2573)	1
	% Cu = 1.26/1.65 x 100 = 76.2% (allow 76.0% - 76.4%)	1
	Allow ecf after each stage of the calculation	
	Total	**14**

Question	Expected Answers	Marks
4 (a)	Geometric or *cis* and *trans*	1
(b)		
	Accept other possible projections. Brackets and charge are NOT required for the mark	2
(c)	Optical	1
	cis isomer	1
	correct mirror images (allow ecf)	1
		
	Accept other projections. Brackets and charge are not required. Accept a loop for en If optical given in (a) allow *cis/trans* and correct structures in (c) unless *cis/trans* drawn in (b) Reverse names but correct structures = 4 marks for (a), (b) and (c) combined. NB only two marks available for *cis/trans* diagrams regardless of labels	
	Total	**6**

Question	Expected Answers	Marks
5	Co-ordination number is the number of dative covalent / co-ordinate bonds formed (with central transition metal / ion)	1
		
	Suitable charge / brackets needed for these examples Square planar tetrahedral octahedral 90^O 109.5^O 90^O	
	Two marks for each type with suitable example and correct name of shape and bond angle. Clear 3-D diagram with correct bond angle for a correct complex will receive 2 marks	6
	$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$ / other suitable correct equations	1
	Shape changes from octahedral to tetrahedral	1
	Co-ordination number changes from 6 to 4 } } 1 mark for both Charge changes from +2 to -2 }	1
	(Mark for co-ordination number and charge can be taken from equation	
	Quality of Written Communication: 1 mark awarded for the correct use in context of at least 2 of the following terms; Square planar, tetrahedral, octahedral, dative, covalent, co-ordinate,	1
	Total	**11**

2816/01 Unifying Concepts in Chemistry/ Experimental Skills 2 Written Paper

Question	Expected Answers	Marks
1(a)	$K_c = \frac{[H_2]\,[I_2]}{[HI]^2}$ ✓	1
1(b)(i)	HI: 0.28 ✓ H_2: 0.11 ✓	2
1(b)(ii)	Use of $K_c = \frac{0.11 \times 0.11}{0.28^2}$ to generate a calculated value ✓ = 0.15 ✓ (2 significant figures) (calc. value: 0.154336735) no units ✓ *There must be some response here, not left blank.* If [HI] = 0.39 mol dm^{-3} (common mistake), K_c = 0.07955292571 (calc value) = 0.080 to 2 sig figs Do **NOT** accept 0.08 mol dm^{-3} (1 significant figure)	3
1(c)	K_c doesn't change ✓ Composition stays the same **OR** equilibrium does not move ✓	2
1(d)	K_c increases ✓ (forward) reaction is endothermic **OR** reverse reaction is exothermic ✓	2
1(e)	I : Cl = $\frac{78.15}{127} : \frac{21.85}{35.5}$ **OR** 0.615 : 0.615 ✓ **A**: ICl **OR** any multiple, eg I_2Cl_2, etc ✓ *ICl with no working scored 2 marks.* $HI + Cl_2 \longrightarrow ICl + HCl$ ✓ **ACCEPT** $2HI + Cl_2 \longrightarrow 2ICl + H_2$ *Accept multiples from identification of* **A**. *Accept equation based on an incorrect formula for A but ONLY if a compound of I and Cl* **B**: I_2Cl_6 ✓ $2HI + 4Cl_2 \longrightarrow I_2Cl_6 + 2HCl$ ✓ **ACCEPT** $2HI + 3Cl_2 \longrightarrow I_2Cl_6 + H_2$ ✓ *Accept equation based on an incorrect formula for B but ONLY if a compound of I and Cl*	5
	Total:	**15**

Question	Expected Answers	Marks
2(a)	3 ✓	1
2(b)	$k = \frac{6.90 \times 10^{-7}}{(2.80 \times 10^{-4})^2 \times 1.44 \times 10^{-3}}$ ✓ = 6.11 x 10^3 ✓ (calculator 6.111819728 × 10^3) units: $dm^6\ mol^{-2}\ s^{-1}$ ✓ **ACCEPT** 6.1 × 10^3 up to calculator value If expression is upside down, calculated value = 1.636173913 1.6 up to calculator value would score 1 mark for the numerical value **ECF** units $dm^{-6}\ mol^2\ s^1$ If square is missed, calculated value = 1.711309524 1.7 up to calculator value would score 1 mark for the numerical value **ECF** units $dm^3\ mol^{-1}\ s^{-1}$	3
2(c)(i)	Curve downwards with slope gradually levelling off ✓	1
2(c)(ii)	Measure its gradient **OR** slope ✓ (Tangent) at t = 0 **OR** at start ✓ *Either mark could be from triangle shown on graph with y/x*	2
2(c)(iii)	Half-life is constant ✓	1
2(d)(i)	Curve upwards with slope gradually getting steeper ✓	1
2(d)(ii)	rate × 9 **OR** 3^2 ✓ order = 2 (with respect to NO) ✓ *Each marking point is independent*	2
2(d)(iii)	rate × 2^2 × 3 = × 12 ✓	1
	Total:	**12**

Question	Expected Answers	Marks
3(a)	$pK_a = 2.82$ ✓ calculated value = 2.823908741 **ACCEPT** 2.8 up to calculator value	1
3(b)(i)	$K_a = \frac{[H^+]\,[HSO_3^-]}{[H_2SO_3]}$ ✓	1
3(b)(ii)	$1.50 \times 10^{-3} \approx \frac{[H^+]^2}{0.0265}$ ✓ *('=' sign is acceptable)* $[H^+] = \sqrt{1.50 \times 10^{-3} \times 0.0265} = 6.30 \times 10^{-3}$ mol dm^{-3} ✓ pH = –log$[H^+]$ = –log 6.30×10^{-3} = 2.20 ✓ *(Stand alone mark; ie* pH –log(0.0265) = 1.58 can be awarded 1 mark*)* If all figures kept in calculator, value = 2.200331434 **ACCEPT** 2.2 up to calculator value If no square root, pH =. 4.40	3
3(b)(iii)	a small amount of second dissociation **OR** it is a diprotic acid ✓ **ACCEPT** equilibrium concentration H_2SO_3 is less than the initial concentration.	1
3(c)(i)	ionic product (of water) ✓	1
3(c)(ii)	$K_w = [H^+]\,[OH^-]$ ✓	1
3(d)	$[H^+] = \frac{1.0 \times 10^{-14}}{0.0265}$ **OR** 3.77×10^{-13} **OR** pOH –log(0.0265) = 1.58 ✓ pH = –log(3.77×10^{-13}) **OR** 14 – 1.58 = 12.42 ✓ calculated value = 12.42324587 **ACCEPT** 12.4 up to calculator value	2
3(e)	**C**: $KHSO_3$ ✓ $KOH + H_2SO_3 \longrightarrow KHSO_3 + H_2O$ ✓ **D**: K_2SO_3 ✓ $2KOH + H_2SO_3 \longrightarrow K_2SO_3 + 2H_2O$ / $KOH + KHSO_3 \longrightarrow K_2SO_3 + H_2O$ ✓ If **C** and **D** are the wrong way around award 3 max by **ECF** If H_2SO_4 used throughout, award 3 max by **ECF**	4
	Total:	**14**

Question	Expected Answers	Marks
4(a)	$C_2H_4O_3$ ✓	1
4(b)	**Stage 1:** $ClCH_2COOH + 2NaOH \longrightarrow HOCH_2COONa + NaCl + H_2O$ scores two marks ✓✓ $ClCH_2COOH + NaOH \longrightarrow HOCH_2COONa + HCl$ scores one mark ✓ $ClCH_2COOH + NaOH \longrightarrow ClCH_2COONa + H_2O$ scores one mark ✓ $ClCH_2COOH + NaOH \longrightarrow HOCH_2COOH + NaCl$ scores one mark ✓ **Stage 2:** $HOCH_2COONa + H^+ \longrightarrow HOCH_2COOH + Na^+$ ✓ **ACCEPT ECF** from $ClCH_2COONa$ forming $ClCH_2COOH$	3
4(c)	buffer minimises **OR** resists pH changes ✓ $HOCH_2COOH \rightleftharpoons HOCH_2COO^- + H^+$ ✓ **For explanation below, accept HA and A^- OR other weak acid** added alkali reacts with H^+ / $H^+ + OH^- \rightarrow H_2O$ ✓ $\rightarrow HOCH_2COO^-$ / Equil → right (to counteract change) ✓ $HOCH_2COO^-$ reacts with added acid or H^+ ✓ $\rightarrow HOCH_2COOH$ / Equil → left (to counteract change) ✓ $[H^+] = 10^{-pH} = 10^{-4.4} = 3.98 \times 10^{-5}$ ✓ $\frac{[HOCH_2COOH]}{[HOCH_2COO^{\$}]} = \frac{[H^+]}{K_a}$ **OR** $\frac{[HOCH_2COO^{\$}]}{[HOCH_2COOH]} = \frac{K_a}{[H^+]}$ ✓ $\frac{[HOCH_2COOH]}{[HOCH_2COO^{\$}]} = \frac{3.98 \times 10^{\$5}}{1.48 \times 10^{\$4}}$ **OR** 0.27 **OR** $\frac{[HOCH_2COO^{\$}]}{[HOCH_2COOH]} = \frac{1.48 \times 10^{\$4}}{3.98 \times 10^{\$5}}$ **OR** 3.7 ✓ **QWC:** Buffer explanation includes discussion of equilibrium shift ✓	2 4 3 1